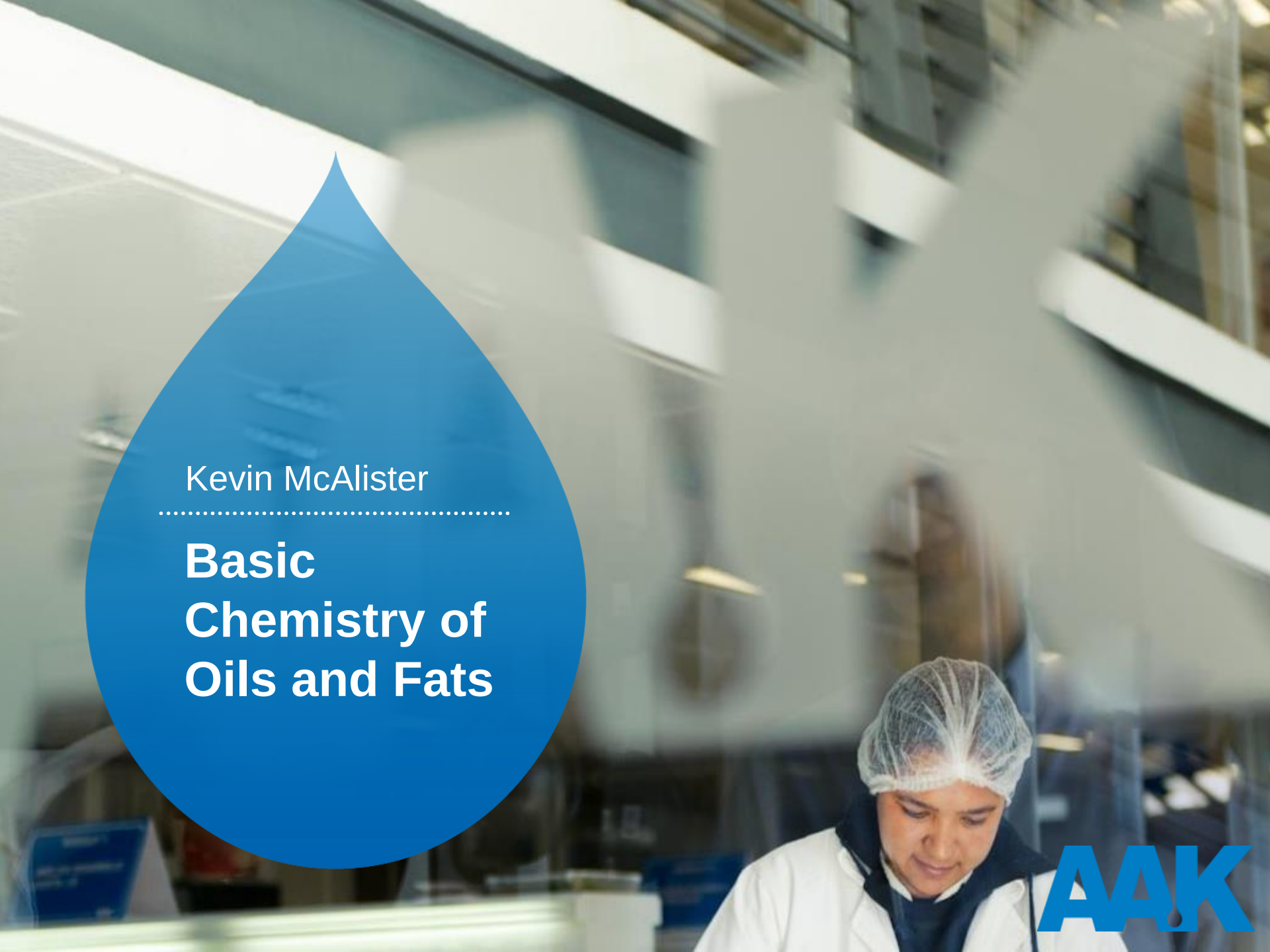


Kevin McAlister

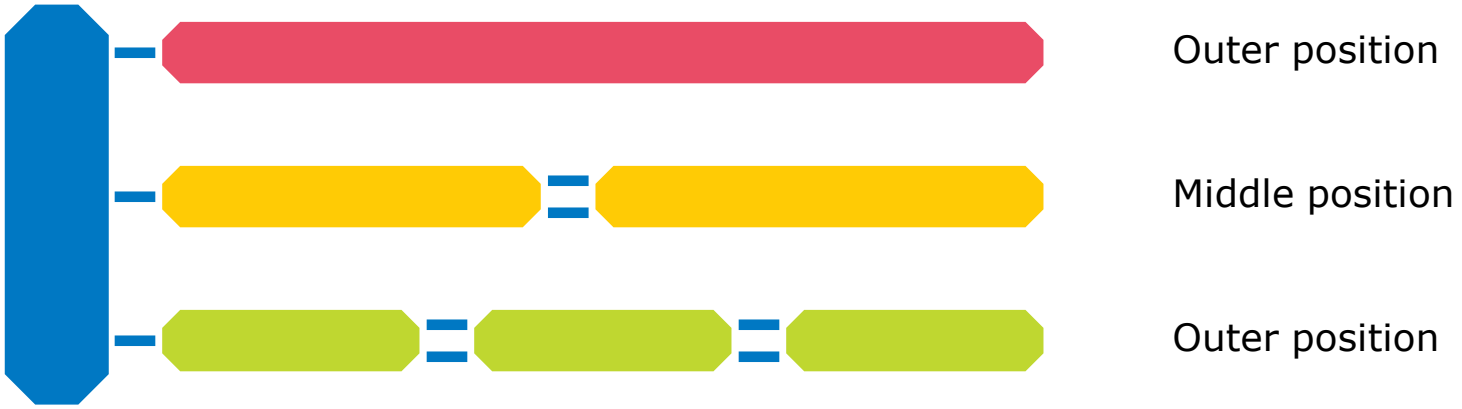
Basic Chemistry of Oils and Fats

What are fats and oils?

- Fats are solid at room temperature
- Oils are liquid at room temperature
- All fats and oils are mixtures of triglycerides (or triacylglycerols)
- Triglycerides (or triacylglycerols) are made of a glycerol molecule with 3 fatty acid chains attached to it

Triglyceride Structure

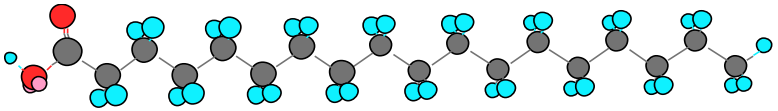
- All oils and fats are based on carbon chains linked together by a glycerol backbone to form a Triglyceride or Triacylglycerol (TAG) molecule.



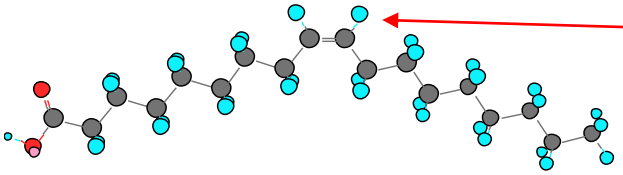
- The characteristics of an oil or fat are determined by the type and length of chain attached to the glycerol backbone

Glycerol Saturated fatty acid Monounsaturated fatty acid Polyunsaturated fatty acid

The three types of fatty acid chain



Saturated – no double bonds



Monounsaturated – one double bond

Polyunsaturated – two or more double bonds

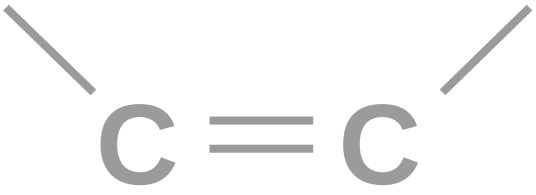
Melting points of saturated fatty acids

Number of Carbon Atoms	Common Name	Melting Point °C
C8.0	Caprylic	16.5
C10.0	Capric	31.5
C12.0	Lauric	43.5
C14.0	Myristic	54.4
C16.0	Palmitic	62.9
C18.0	Stearic	69.6
C20.0	Arachidic	75.5
C22.0	Behenic	80.0

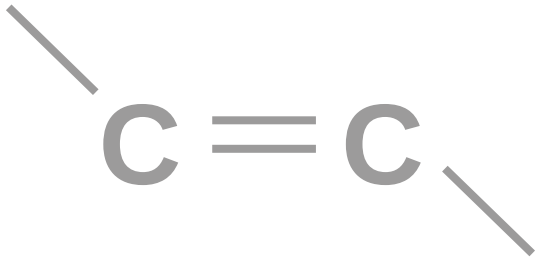
Comparison, Saturated vs Unsaturated

Number of Carbon Atoms	Number of Double Bonds	Common Name	Melting Point °C
C18.0	0	Stearic	69.6
C18.1 trans	1	Elaidic	43.0
C18.1 cis	1	Oleic	13.0
C18.2	2	Linoleic	-5.0
C18.3	3	Linolenic	-11.0

Cis vs Trans Isomers



Cis

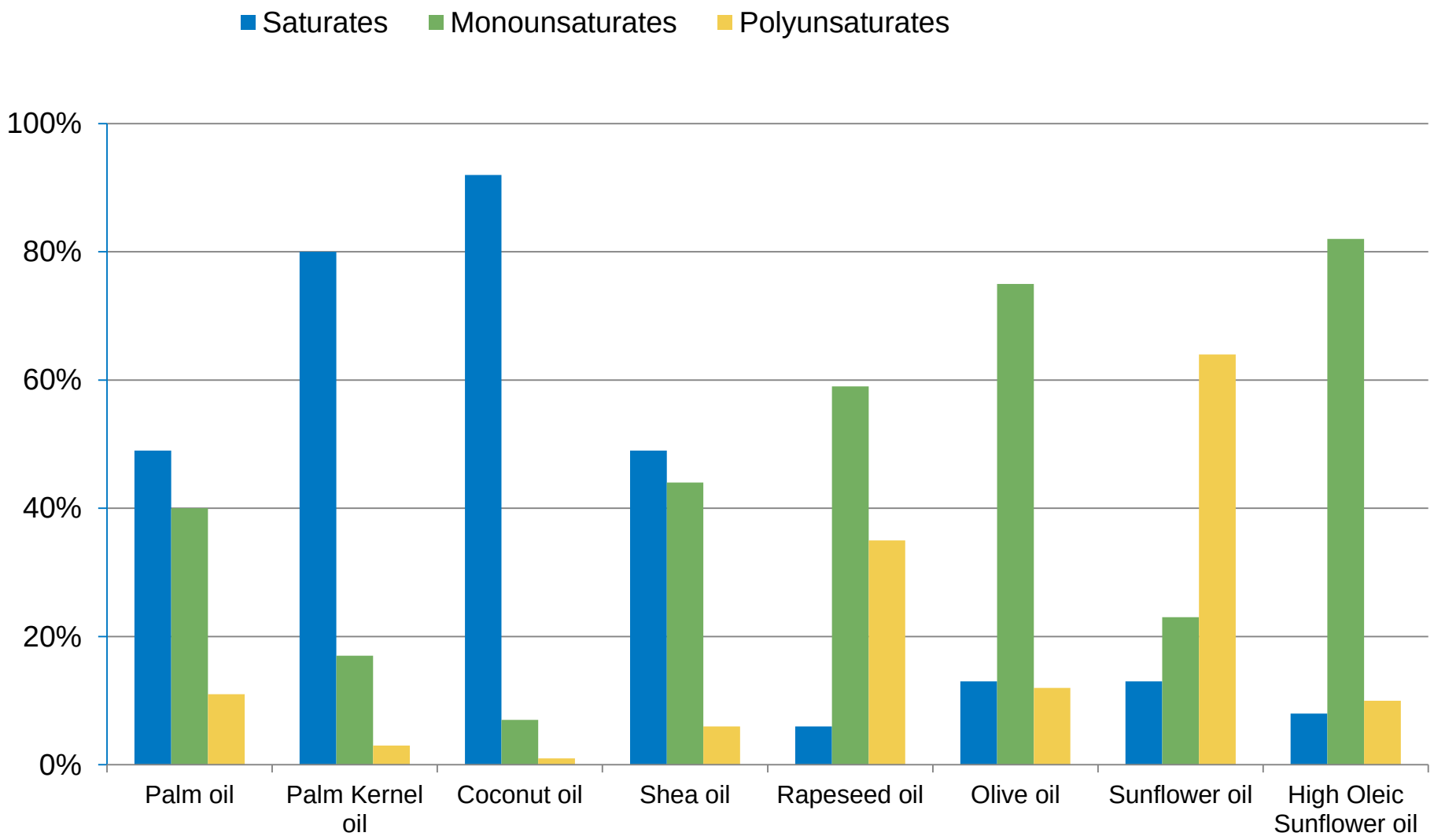


Trans

Typical Fatty Acid Composition

	C8:0	C10:0	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	others
Palm	0	0	0.2	1	42.5	4.6	40	10.9	0.2	0.4	0	0.2
Palm Kernel	4	3	46.2	15.5	8.5	2.5	17	3.1	0	0.2	0	0
Coconut	8	6	47	18	8.5	2.5	7	1.5	0	0	0	1.5
Shea Oil	0	0	0.1	0.1	4.0	44.1	44.2	6.0	0.3	1.2	0	0
Rapeseed	0	0	0	0	4.6	1.7	61.7	19.2	9.5	0.5	1.3	1.5
Olive	0	0	0	0	13	2.5	72	11.5	0.5	0.4	0	0.1
Sunflower	0	0	0	0	6.5	4	25	63	0.3	0.3	0	0.9
High Oleic Sunflower oil	0	0	0	0.1	3.8	3.8	82	8.5	0.1	0.3	0.3	1.1

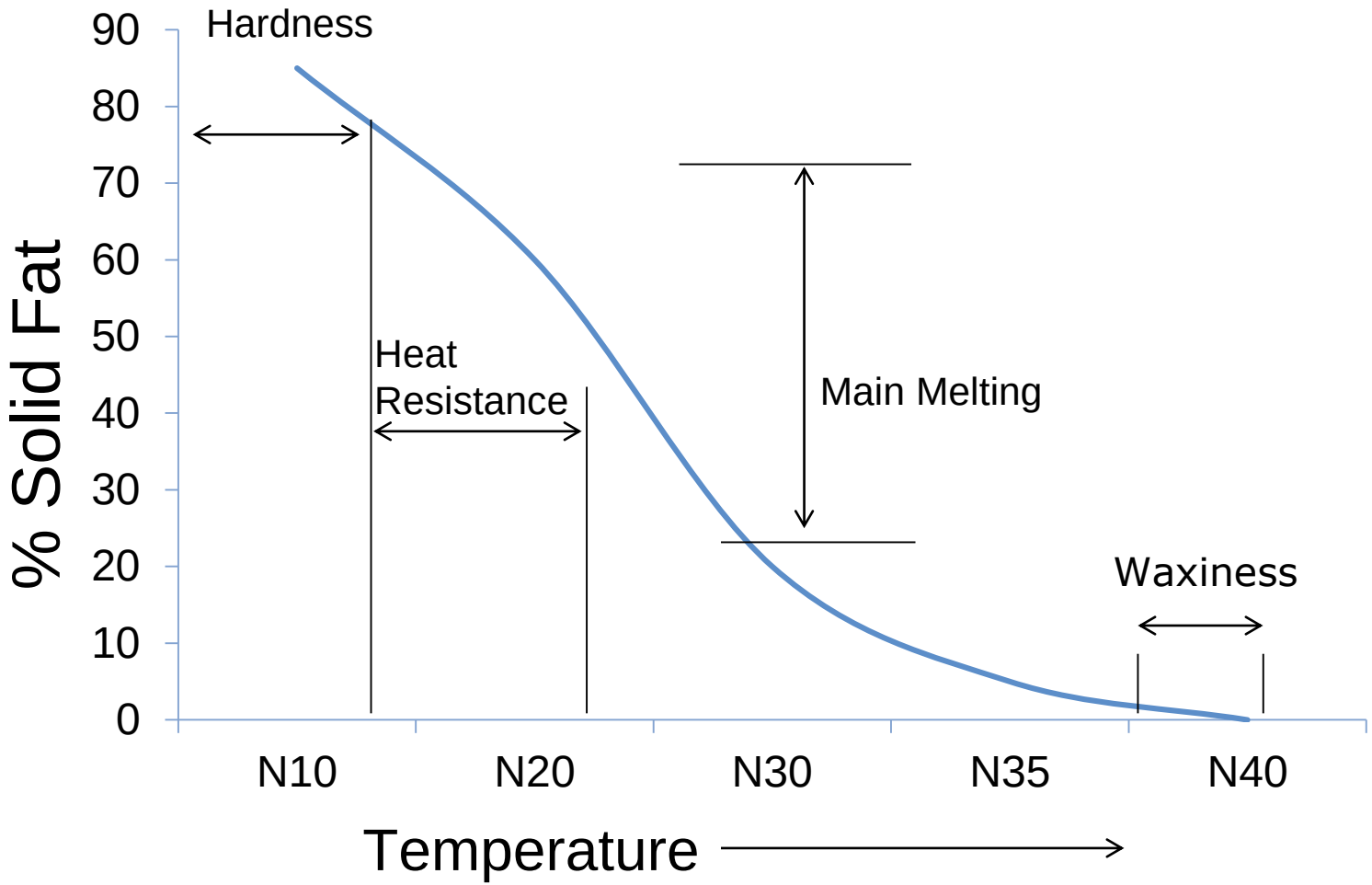
Differences in Composition



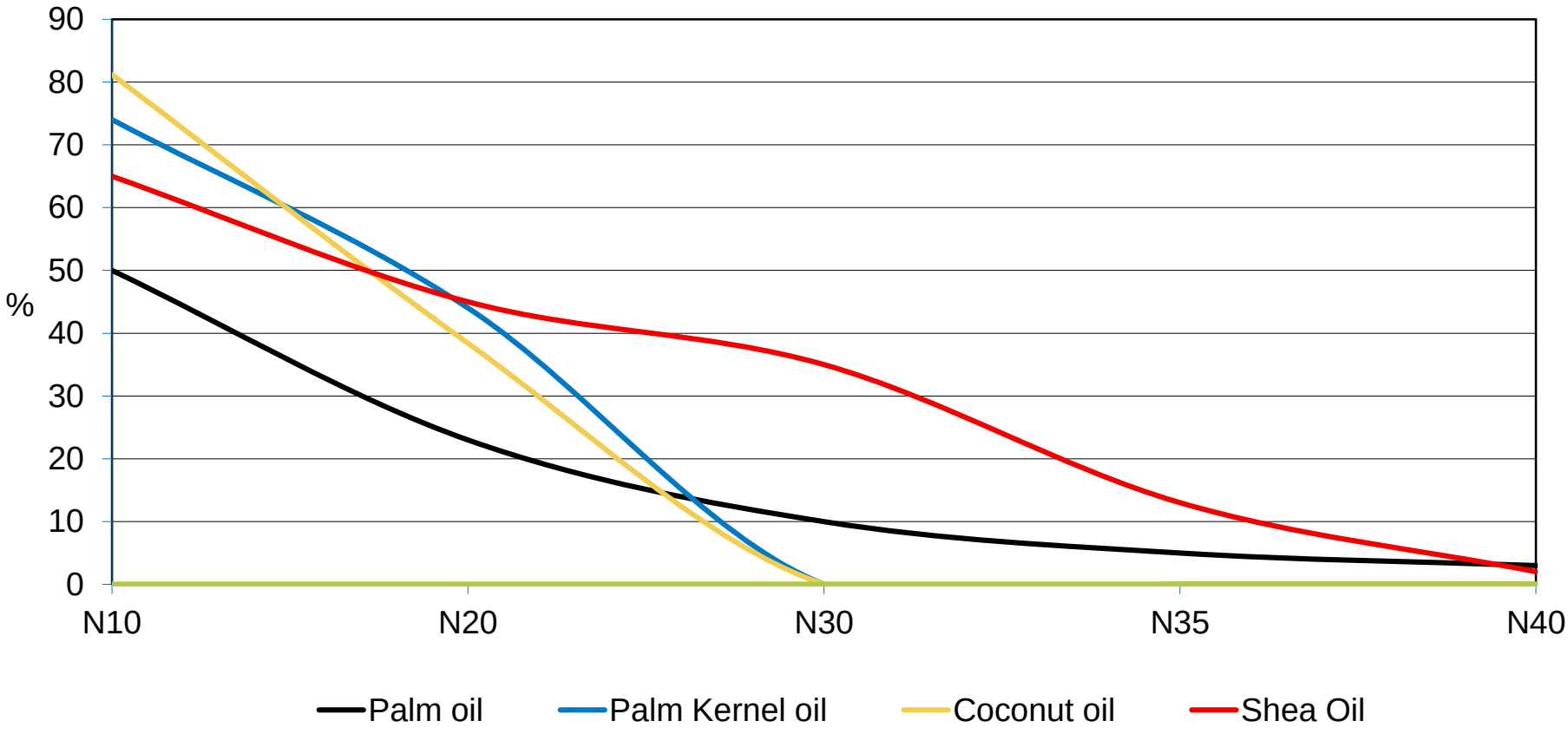
Solid Fat Content

- The solid fat content is the percentage of solid fat in a fat or blend at a particular temperature
- The solid fat content decreases as the temperature is increased
- At the melting point, the solid fat content is zero
- Solid fat content is measured by pulsed (p) NMR
- Solid fat content at 20^{o}C is abbreviated as N20, 30^{o}C as N30, etc

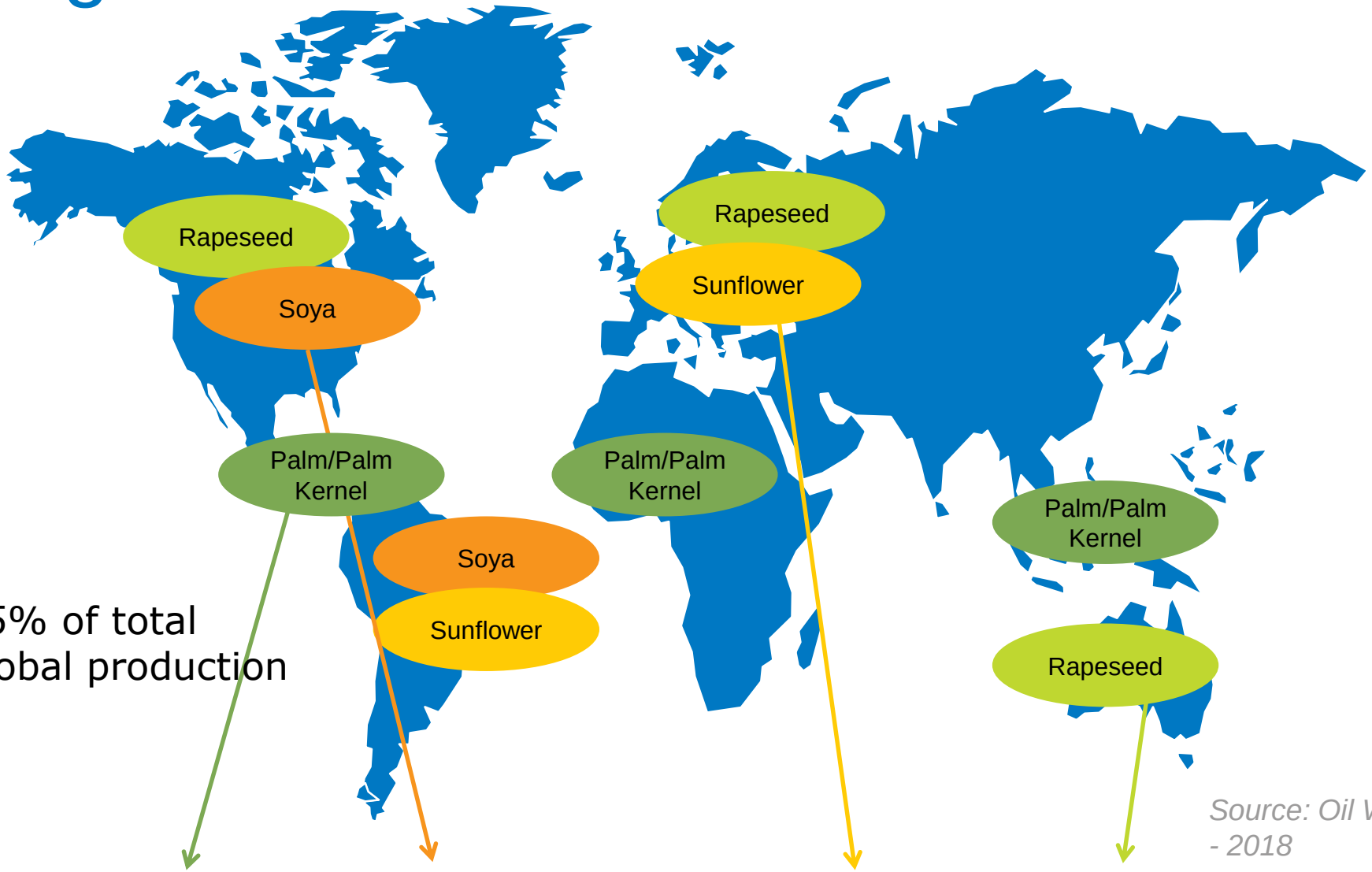
Solid Fat Content



Solid Fat Content



Vegetable Oil Sources



75% of total global production

Source: Oil World - 2018

73m tonnes | 56.5m tonnes | 19.6m tonnes | 26.4m tonnes

Yield per source of oil

Oilseeds

	% Oil
Soyabeans	18 – 20
Rapeseeds	40 – 44
Sunflowerseeds	36 – 44
Maize Germ	50 – 54
Cottonseeds	18 – 20
Seasameseeds	50 – 55
Safflowerseeds	20 – 45
Peanuts	45 – 50

Tree Fruits & Nuts

	% Oil
Coconut (Copra)	65 – 68
Palm Fruit (flesh)	45 – 50
Palm Kernel	45 – 50
Olive (flesh)	ca. 30
Cocoa Beans	ca. 52

Source: Oil World

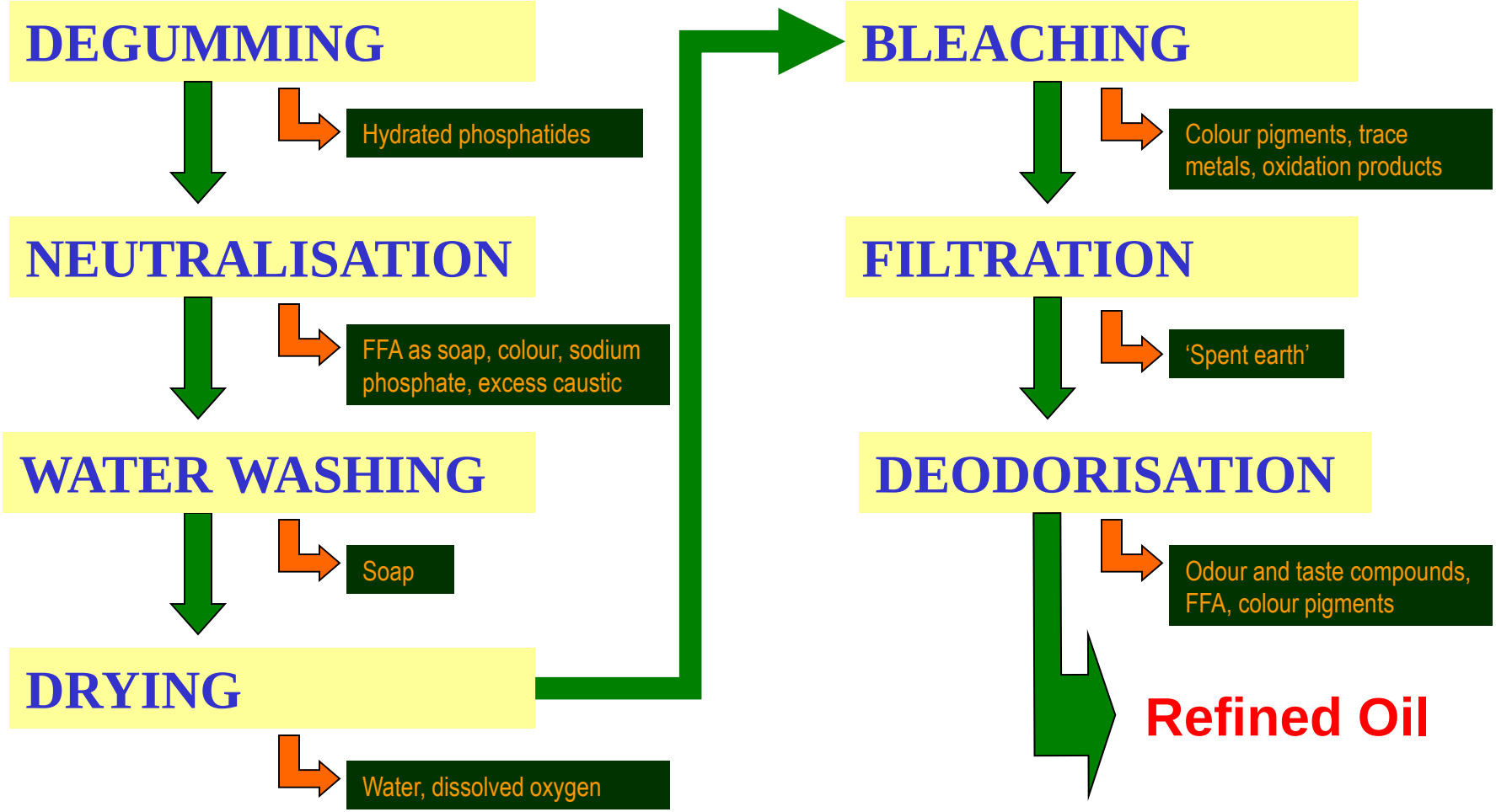
Palm Tree and Fruit

Rapeseed crop and seeds

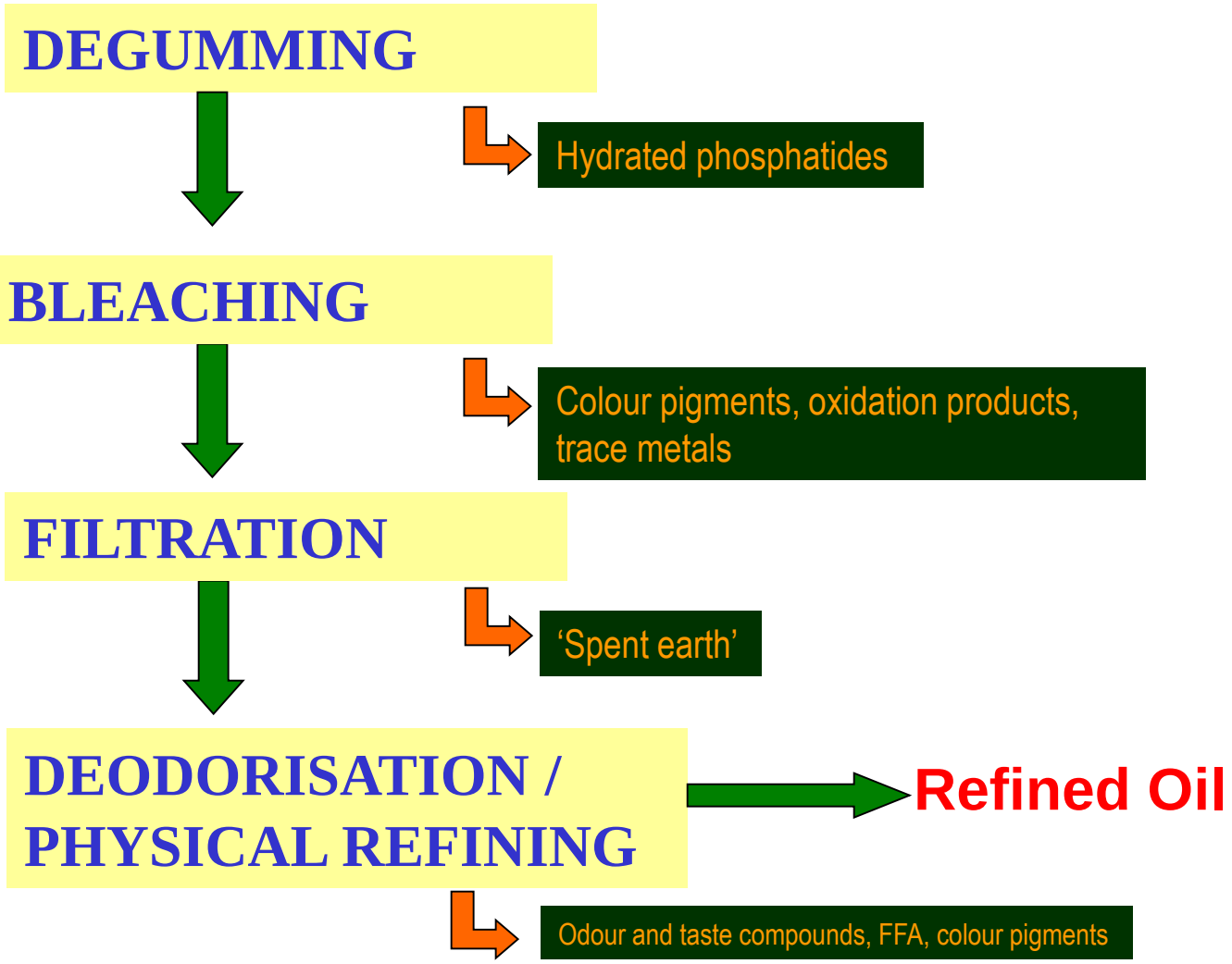
Oil Refining

- Chemical
- Physical

Chemical Refining



Physical Refining



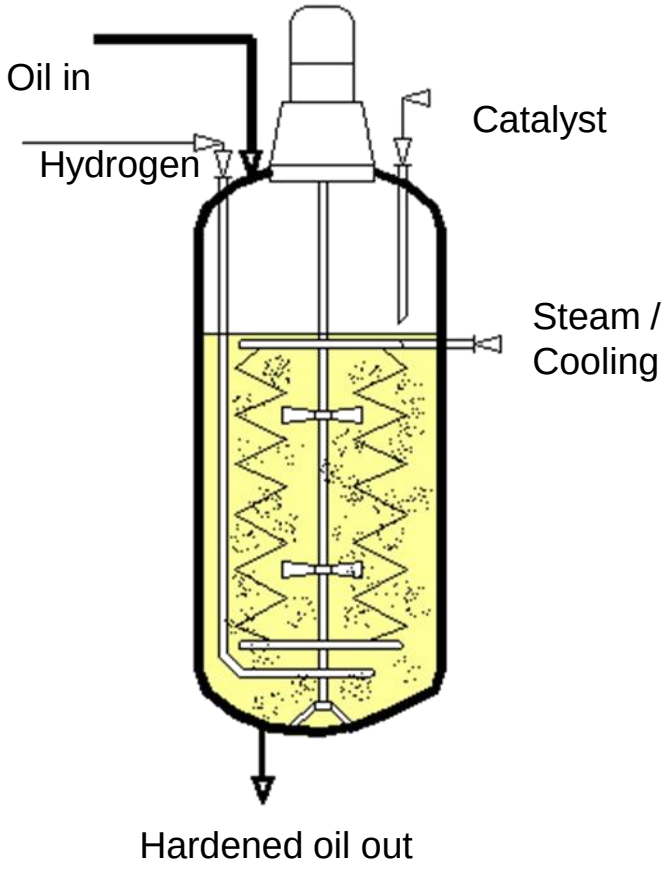
Minor Components

- Free Fatty Acids
- Diglycerides
- Monoglycerides
- Pigments
- Gums (Phospholipids)
- Sterols
- Tocopherols
- Moisture and Impurities
- Odour and Flavour components
- Trace metals
- Oxidised materials
- Other Contaminants
  - Pesticides
  - Polycyclic Aromatic Hydrocarbons
  - Heavy Metals
  - Dioxins / PCB’s

Modification

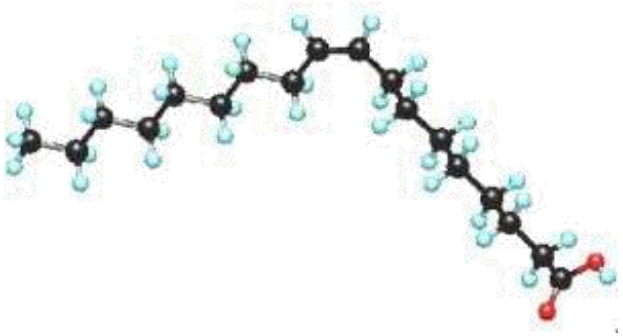
- Blending
- Hydrogenation
- Fractionation
- Interesterification

Hydrogenation

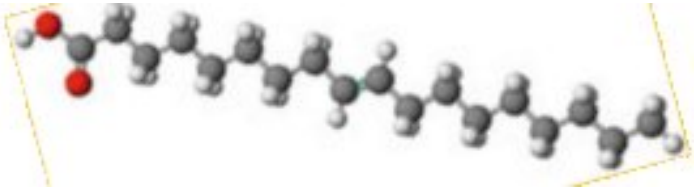


- Hydrogenation is the means by which an oil or fat can be turned into a semi-solid or solid fat
- This is done by reacting the oil with hydrogen in the presence of a nickel catalyst
- Temperature, hydrogen pressure and catalyst may vary
- Temperature 160 - 200°C, pressure 1 – 4 bar to enable the final product to be tailor made to the customers needs

Effect of Hydrogenation



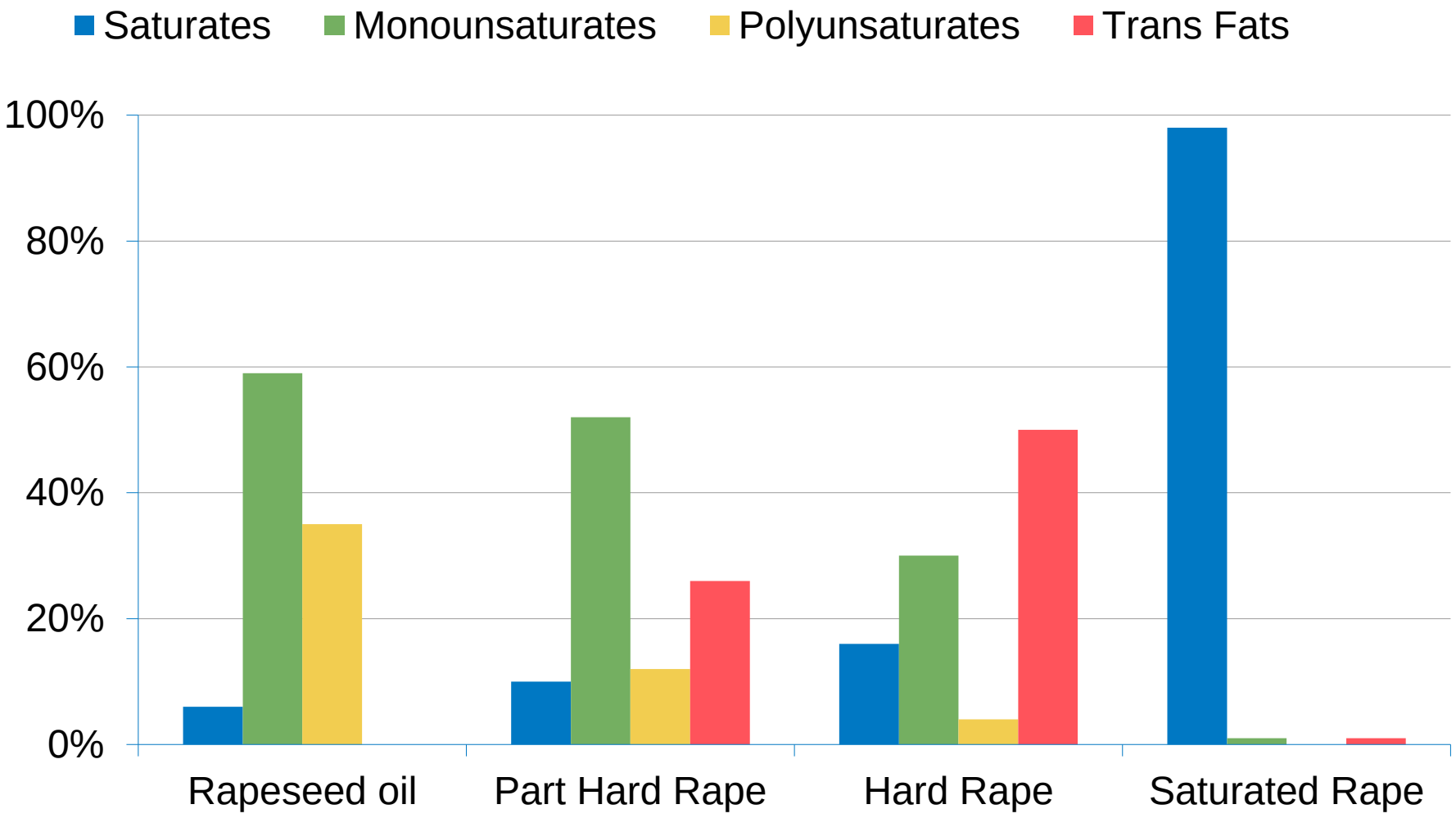
Monounsaturate – Oleic Acid
13C



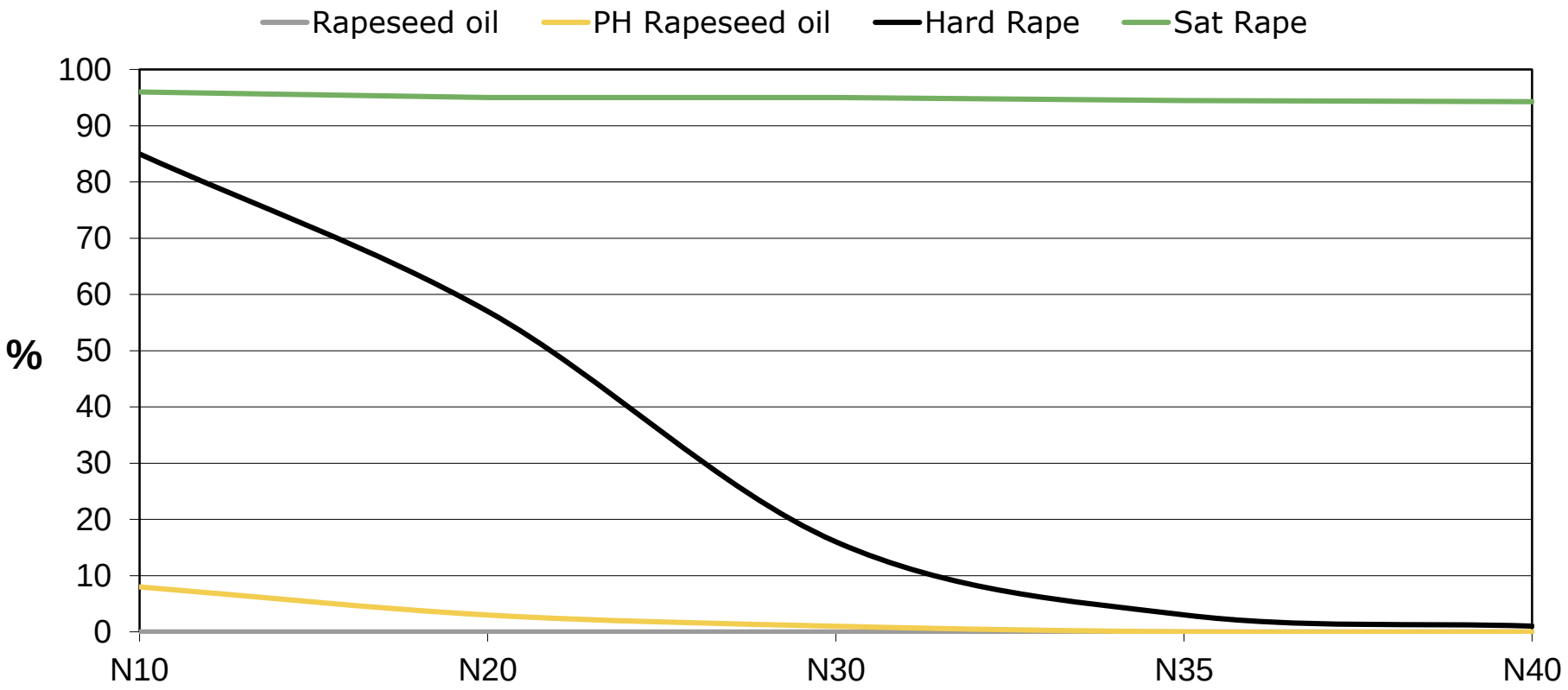
Trans Fatty Acid – Elaidic Acid
43C

Raises melting point, forms trans fatty acids and increases saturates

Effect of Hydrogenation



Effect of Hydrogenation



Hydrogenation

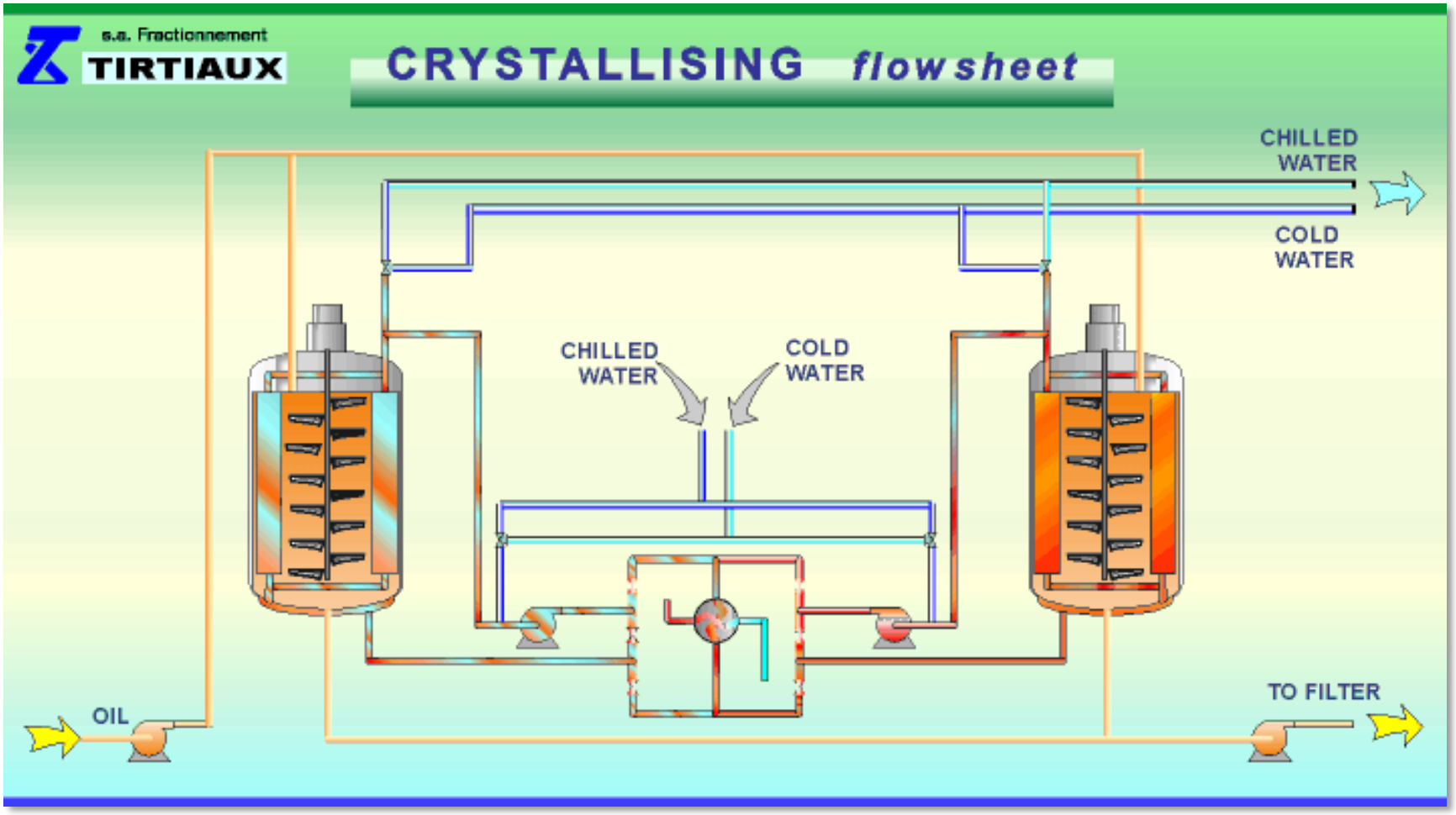
Advantages

- Produces hard fats from liquid oils
- Improves stability
- Very flexible and cost effective – products for a wide range of applications

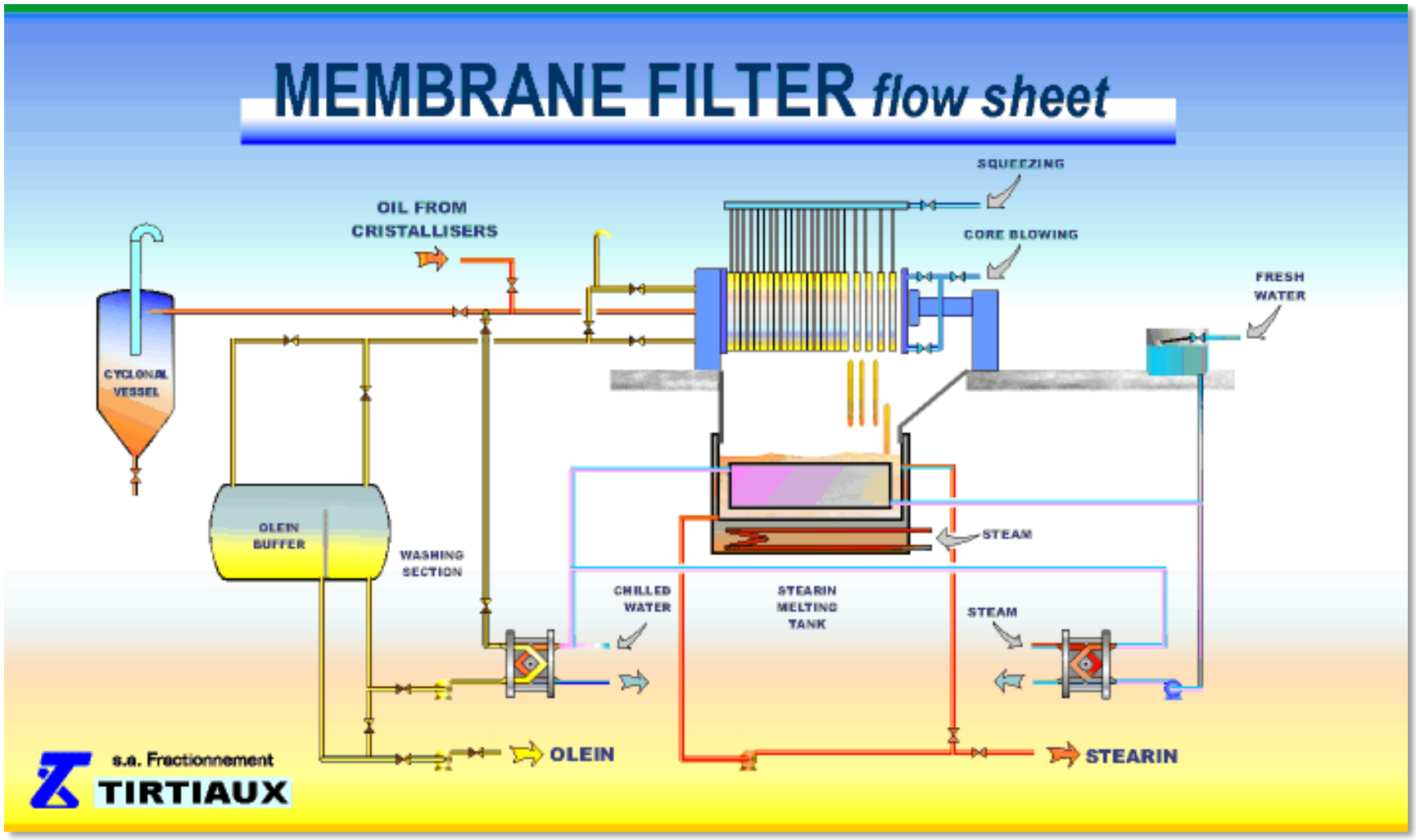
Disadvantages

- Chemical process
- Trans fatty acids produced in partial hydrogenation

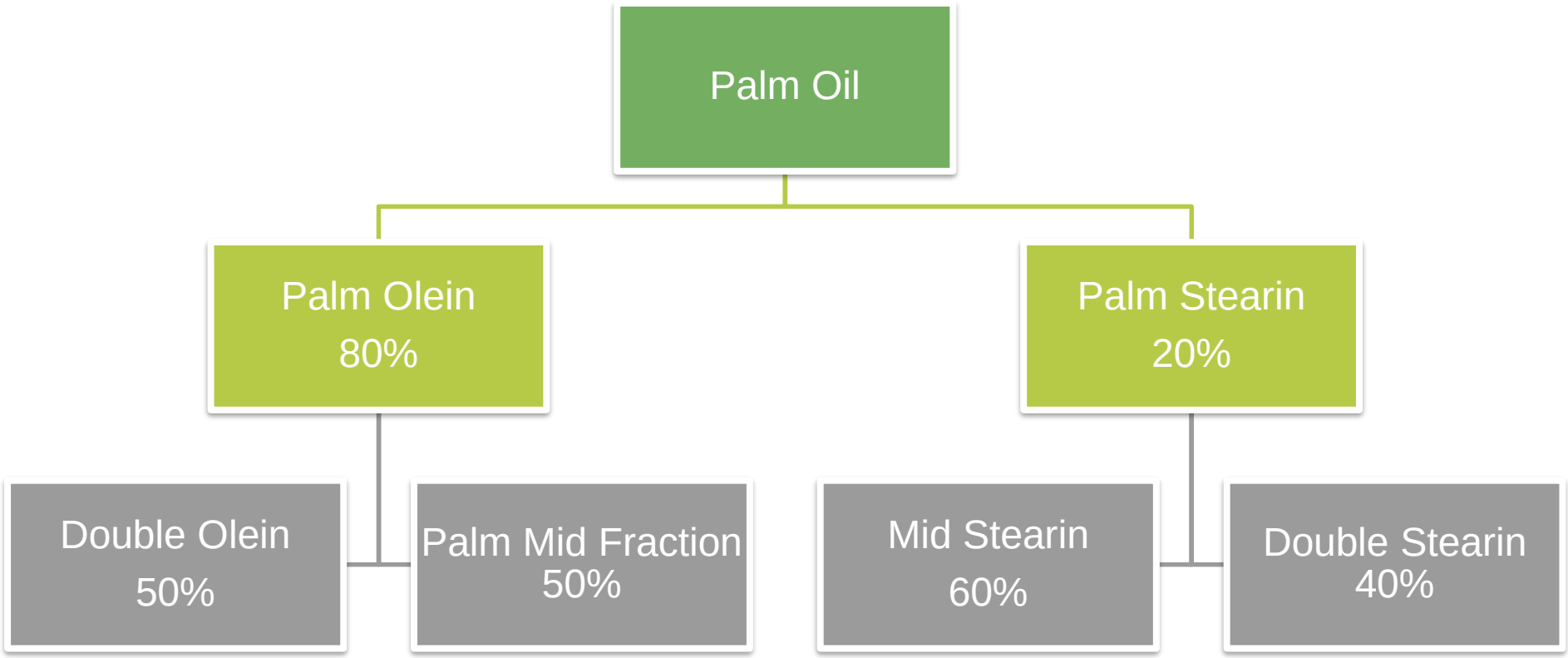
Fractionation



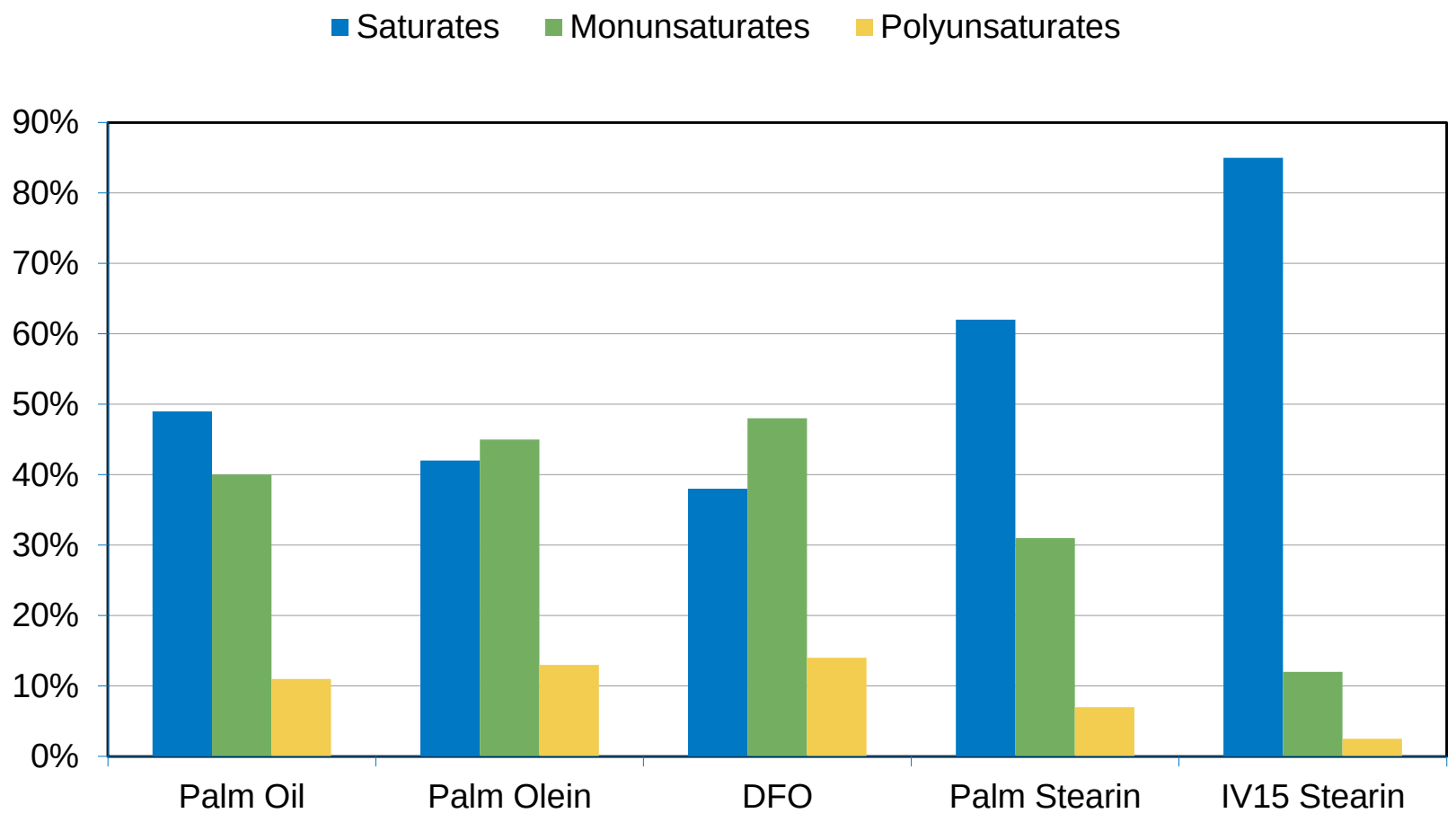
Fractionation



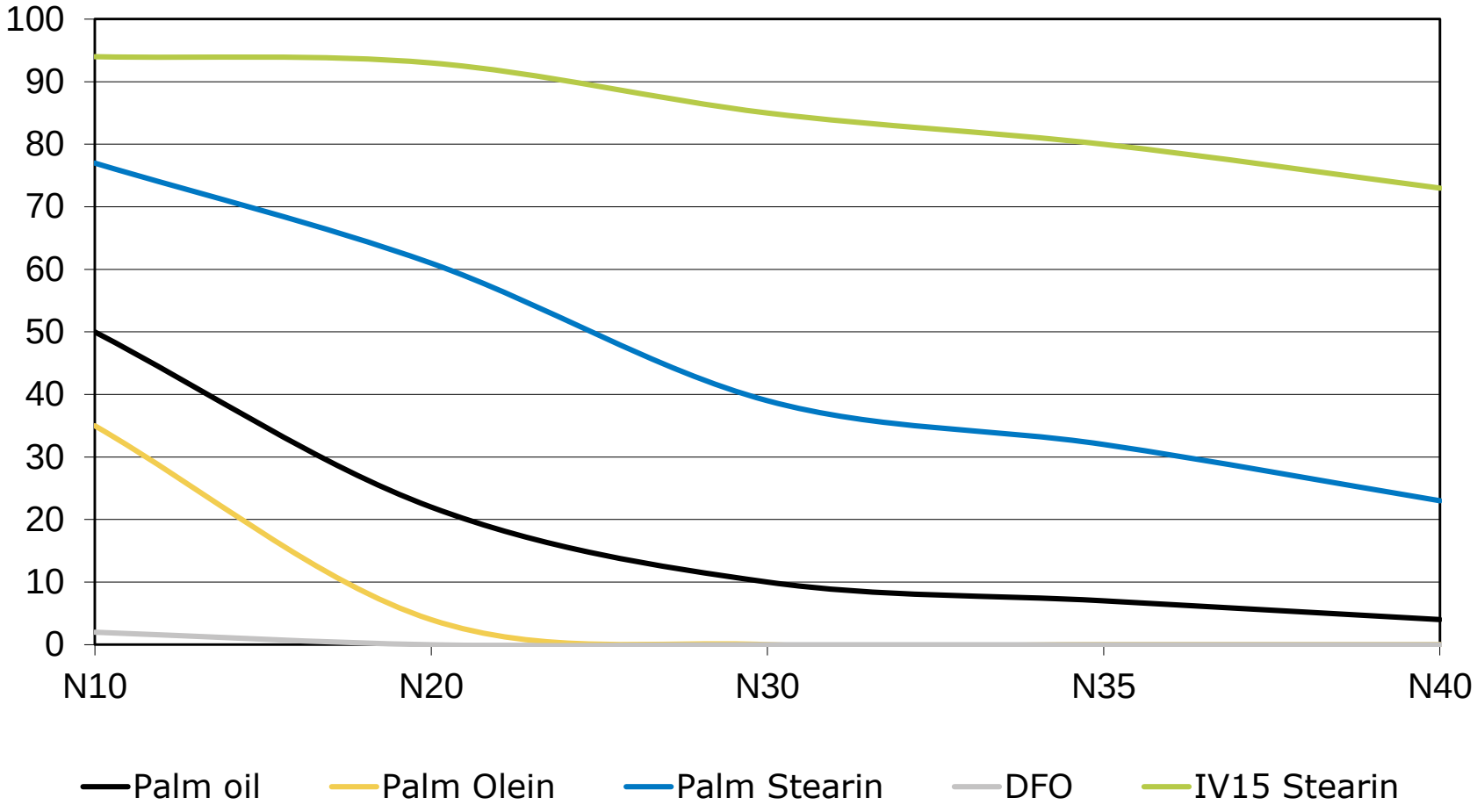
Fractionation of Palm Oil



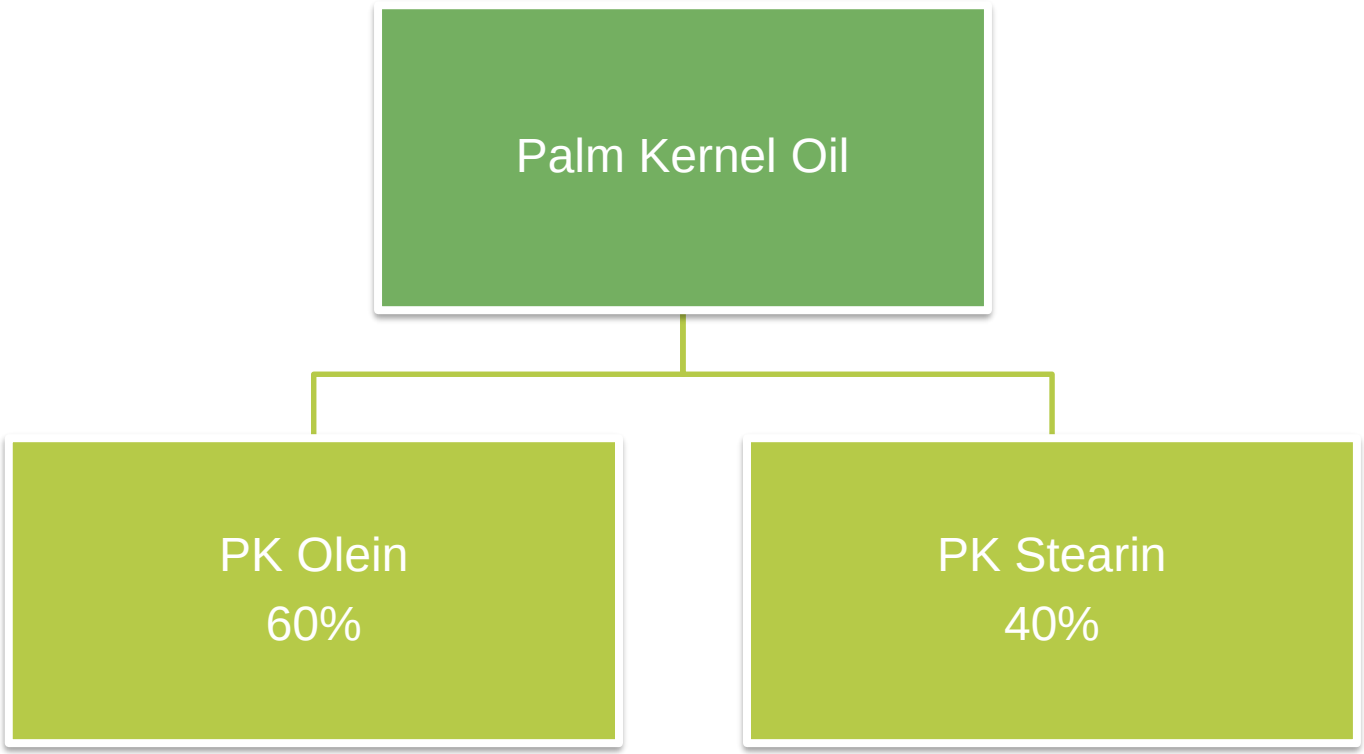
Effect of Fractionation



Effect of Fractionation – Palm Oil



Fractionation of Palm Kernel Oil



Fractionation

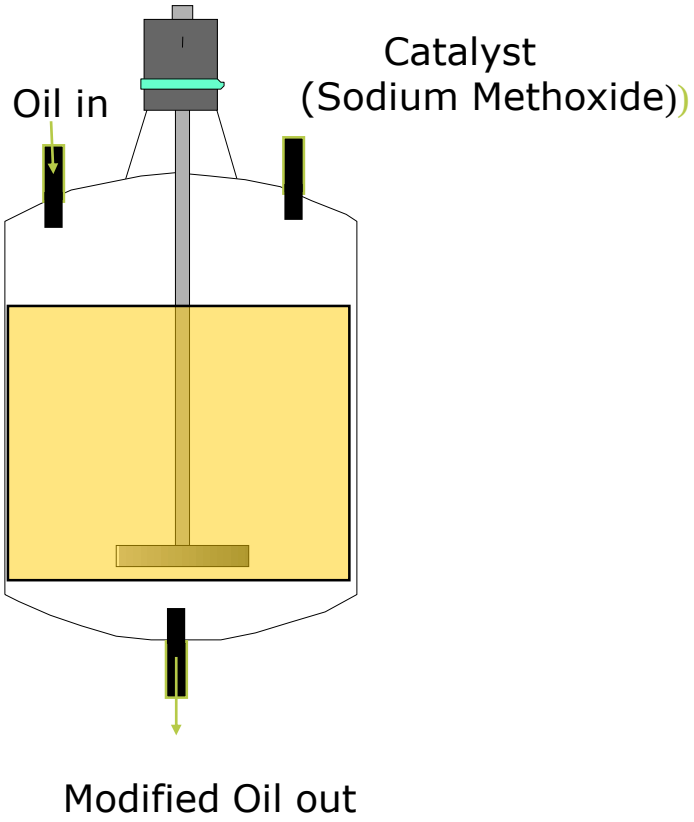
Advantages

- Natural process
- Can make some very useful and specialist products

Disadvantages

- Fixed yield so economics depends on demand for resultant products in the right proportions

Interesterification



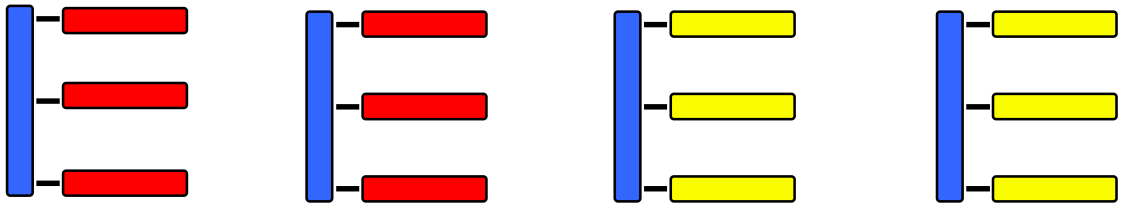
- Interesterification is the process by which the structure of a triglyceride can be changed
- The process involves heating the oil to 100°C under vacuum in the presence of a catalyst (Sodium Methoxide)
- The result is a randomisation of the triglyceride producing a fat with different physical properties

Melting Points of some triglycerides

Triglyceride structure	Number of double bonds	Melting point °C
PPP	0	66.0
OOO	3	-10.0
POP	1	37.0
PPO	1	41.9

Properties are determined by fatty acid and triglyceride composition

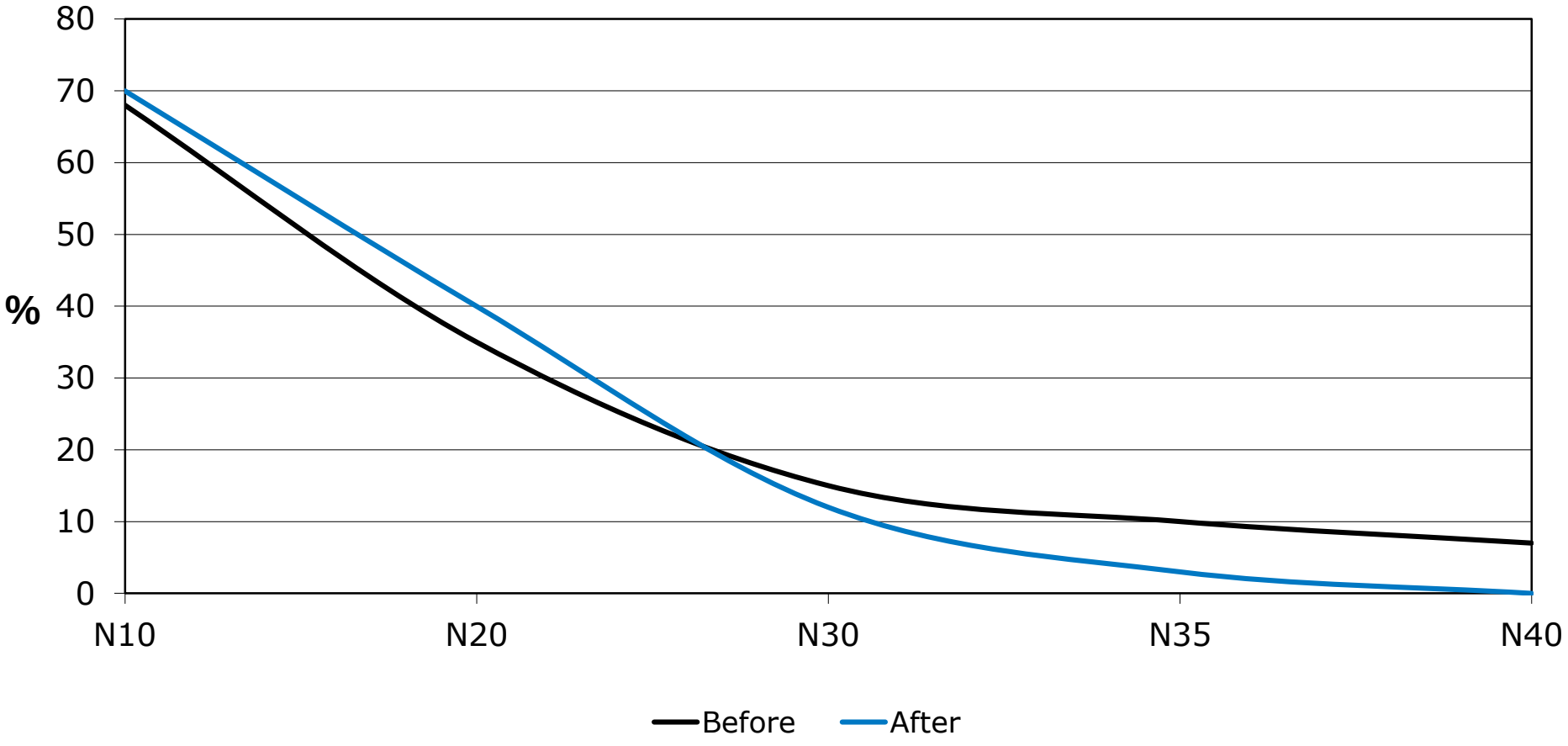
- Feedstock may have this triglyceride composition



- Sodium Methoxide catalyst is added and causes the randomisation of the fatty acids on the glycerine backbone

- The triglyceride composition is totally different from the feedstock yet fatty acid composition is identical

Effects of Interesterification



Interesterification

Advantages

- No trans formed in reaction
- Resultant product usually has more solids than starting material

Disadvantages

- Chemical process
- Complex raw material blends needed to achieve range of finished products
- Does not improve stability

Why there are few Alternatives to Palm

- It is unlikely that any single oil or simple blend of oils will meet the requirements of a current ‘functional’ product that is based on or has an amount of palm oil in it

- It is likely that one or more of the modification techniques already outlined would need to be used, quite possibly following oil blending

Why there are few Alternatives to Palm

Depends upon application as to what can be used, but in summary they are:

- Liquid oils – rapeseed, soyabean, sunflower, maize, olive and their hybridised varieties
- Coconut oil
- Shea
- Other tropical oils such as sal, mango kernel, kokum, illipe etc

- Note that there is limited availability of shea and the ‘other’ tropical oils…..also meaning a significant increase in cost versus palm based products

Discussion / Questions?